The Geological Structure of Tazewell, Russell and Wise Counties, in Virginia.

By. J. P. Lesley.

(*Read before the American Philosophical Society, April 21st*, 1871.)

I was called upon recently to examine a part of the Alleghany Mountain Range, between the New River (Kanawha) in Middle Virginia and the north line of the State of Tennessee, for the purpose of determining the nearest possible approach to a workable coal region of a contemplated Railway from Harper's Ferry on the Potomac to Knoxville in Tennessee.

The geological structure of this part of the United States is so peculiar and so nearly unknown to geologists, or at least unnoticed in any published memoirs, that I have taken some pains to portray it, believing that it will be an acceptable contribution to the literature of the science and to the proceedings of this Society. The present paper is, however, a virtual continuation of my description of the South Virginia Coal region of Montgomery and Wythe Counties, read before this Society in 1862, and published in Vol. IX of its Proceedings, pages 30 to 38.

Professor William B. Rogers, State Geologist of Virginia, is well acquainted, no doubt, with the essential facts about to be described, and probably has materials for a more extensive description of the central belt of the Appalachians among the unpublished archives of the State Geological Survey of Virginia; but I doubt that any sections have been constructed which express more clearly the state of things in a geological sense, than those which I have this opportunity of making known.

Professor James M. Safford, State Geologist of Tennessee, has studied the Southern continuation of the belt, and describes it in his Geology of Tennessee, Nashville, 1869. But the sections given in that valuable work, which has cost its author so much time, skill and labor to prepare, and for which American Geologists are most grateful, are only adapted for general description, not being drawn to a natural scale, and are not of use for the critical study of the dynamic problem here offered to the consideration of structural geologists.

The map which accompanies this paper was made to show the railway avenues through the region above named, by bringing out clearly its main *topographical* features. I have colored it to show to the eye its main *geological* features, especially those due to the lines of Downthrow, which are also the lines of limit for the Coal Measures. I have confined the coloring within narrow limits so as not to obscure the prime facts. No distinction is made therefore between the Calciferous, Trenton, Birdseye, Black River and Hudson River formations, all of them being colored

blue, representing the *limestone valley formations*, Lower Silurian, Nos. II and III of the Pennsylvania nomenclature.

The Oneida Conglomerate, Shawngunk Grit, and Medina Sandstone, Middle Silurian, No. IV, are left uncolored, to make their mountain character more conspicuous. The Upper Silurian, Clinton, No. V, carrying the Dyestone, Fossil Iron Ore, is colored red, to catch the eye, because of its practical importance for railway purposes, and because it is the red formation of the North, *par excellence*, although it is not so marked in nature along its southern outcrops. If the native coloring of the soil were to govern the tinting of the map the Hudson River slates (No. III) would require this pigment.

The Devonians are represented by a Vandyke brown wash (Nos. VIII, IX, X), and the Coal Measures by a wash of Payne's gray. No color is allowed for No. XI., which shows so prominently on the geological map of Pennsylvania in red, because its outcrop is feeble here and *not* especially red.

The main features of the topography are quite correct (except near its eastern end, of which I can say nothing); and it distinctly shows how the mountains are made, by the downthrows, to run in pairs, with a "poor valley" between each pair, consisting of Devonian Sandstones and Upper Silurian shales containing the Clinton, Dyestone, or Fossil Iron Ore; and how the pairs are separated by wider Lower Silurian limestone or "rich" valleys, containing the villages and farms of blue grass and scattered and probably extensive deposits of Brown Hematite Iron Ore, which I have *not* colored.

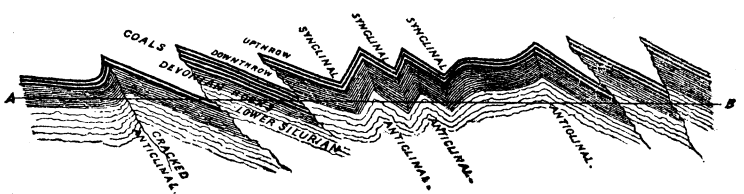
The black lines 1, 2, 3, 4, &c., show where the vertical geological sections in this report are to be looked for on the map.

There is no map of this country worthy of the name. I have copied the State map and then changed its details according to my observations. The geology is perfectly simple, when one has the key to it. The key to it is given by the pairing off of the mountains along the Downthrows.

I begin then with this curious and all important phenomenon. Fig. 1, shows it in a *purely ideal* way; but reference must be made to Sections 1, 2, 3, 4, &c., for its *actual* representation in different places.

Fig 1.

IDEAL CROSS SECTION, SHOWING THE CRACKS OR DOWNTHROWS.



What the power was, which cracked the anticlinal and synclinal curves,

and shoved the 10,000 feet of Carboniferous, Devonian, and Silurian Formations over each other, like cakes of ice in a river freshet, it would be premature here to discuss.

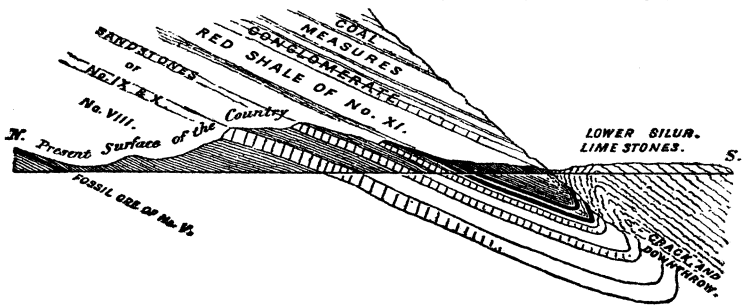
The consequence has been, that along the straight lines of these cracks —lines running for fifty or a hundred miles,—the coals at the top of the system abut against the limestones near its bottom.

Another consequence has been that no coal is to be found but on the north side of each crack. The whole mass of rocks above the line A—B has been removed (it is needless to describe the process, which is still going on and can be studied by any observer), so that the vast coal field which once covered this country is no longer in existence ; and the only remnants of it left are long stripes, a few hundred *yards* wide, running along the north lip of each crack.

A third, and equally important consequence, has been, that even this poor remnant of the Coal-Measures, where it is left, consists of only the very lowest bed or the two lowest beds of the Coal Measures, the poorest of all the coal beds of the system. Fig. 2 will show how this result occurs :

Fig. 2.

SHOWING THE COAL BEDS LEFT IN THE DOWNTHROW



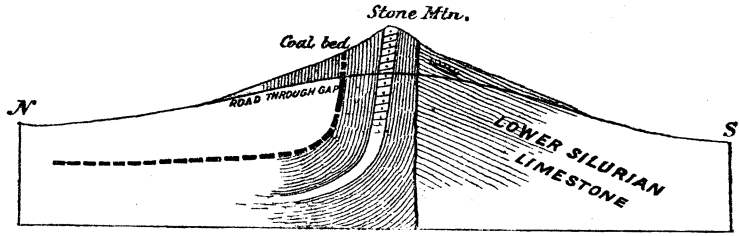
It is not until, going north 30° west, several such downthrows with their comparatively worthless coal fields (so to call them) have been passed, that the real coal field of the country is reached. Its southern edge runs along a straight downthrow lying just north of the Clinch River.

I shall first take up this line at Guest's River, in Wise County, and follow it northeastward, ascending Clinch River ; and I will give sections of its Coal Measures, wherever I studied them.

Stone Mountain, which is the south border of the Guest River Coal Fields, in Wise County, is cut throughby Powell's River at the Big Gap. Some miles further east its summit is notched by a wind-gap (Little Gap), through which the turnpike from Wise County Court House (Gladesville) to Scott County Court House (Estillville) passes. The *lowest coal bed* is opened on the side of the road a quarter of a mile before

reaching the gap; that is, high up the southern face of the mountain. The coal bed is 4 feet thick, and vertical. The core of the mountain is a vertical Conglomerate Sandrock. On the south face of the mountain are cliffs of Lower Silurian limestone. A fault, therefore, runs through the mountain lengthwise, thus:

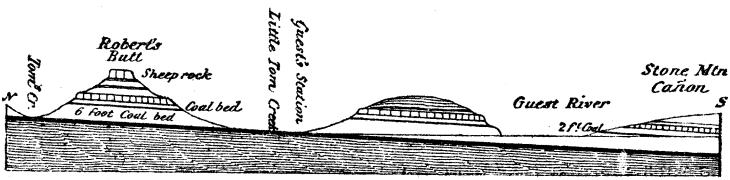
No. 1 SECTION LINE ON THE MAP.



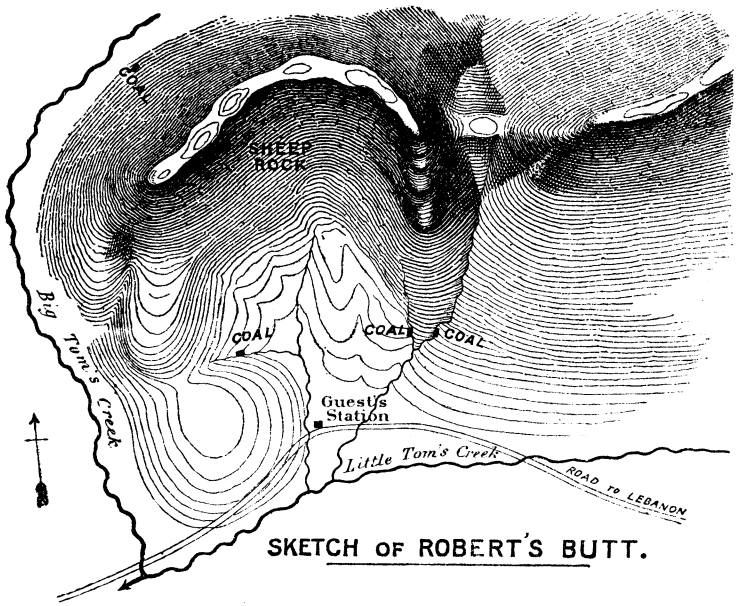
This section, however, I did not myself see; but the information from which I construct it was given to me so clearly, and agrees so exactly with what I saw myself further east, that I have no hesitation in assigning it a place in this report, without endorsing it more specially.

On the west side of Guest River, two miles below the mouth of Tom's Creek, a *two-foot coal bed* is mined; it lies nearly flat, under cliffs of horizontal conglomerate rock. Below this place, the river enters the cañon, through which it rushes for two miles before entering the Clinch River. Vertical walls of conglomerate, hundreds of feet high, stand opposite each other. This is the natural gate for a railway line to the Wise County and Kentucky Coal Field.

SECTION 2 ON THE MAP.

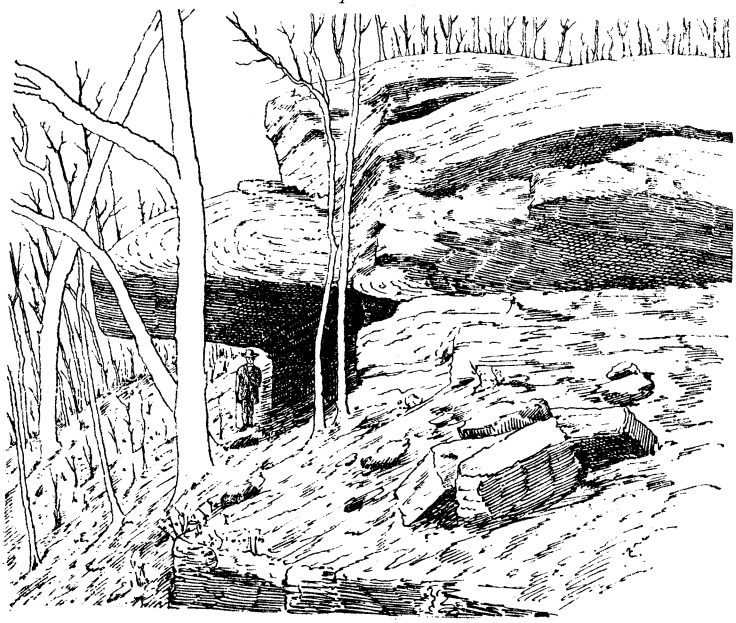


Coal beds are opened up and down Tom's Creek and its branches. One coal bed, from 5 to 6 feet thick, runs through the bases of all the hills, nearly at water level, and almost horizontal. It is mined for family use in the gulches back of Guest's Station (an old log fort, now a store and, although half a mile from the mouth of Tom's Creek, overflowed whenever Guest River is in high freshet), and by Mr. Jessee, and for several miles still higher up Tom's Creek. It is mined up Little Tom's Creek, and on Crab Orchard Creek, as a fine six (6) foot bed of rather handsome flaming coal, solid enough to wagon over rough roads, and not making much ashes or clinker in the grate. It is at least equal to



SKETCH OF ROBERT'S BUTT.

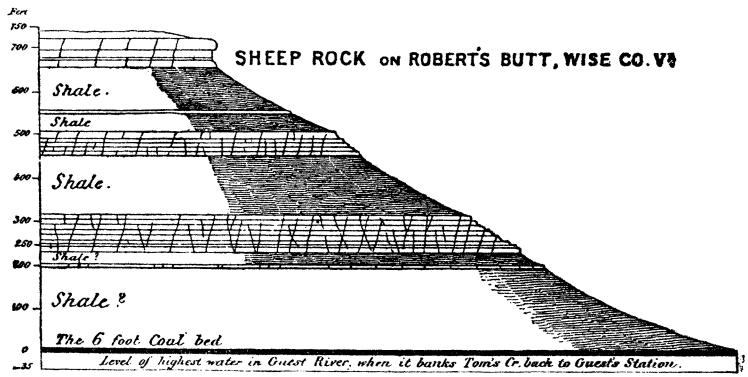
The Great Sheep Rock on Robert's Butt



the general run of the Lower Coal Measure coals in the Bituminous Coal Basins of the Susquehanna West Branch and the Conemaugh. I saw no other beds here; but there must be others both below it and above it; for the beforementioned two-foot bed ought to be above it, as the above section (2) shows.

I made a measured section of one of these hills, called Robert's Butt (over 700 feet high, and capped with a fragment of the great conglomerate sandrock which once covered all the country), as a specimen of the barriers which separate all these streams from one another, in the coal field, and to show how impracticable any railroad line must be which does not follow closely the great water-courses.

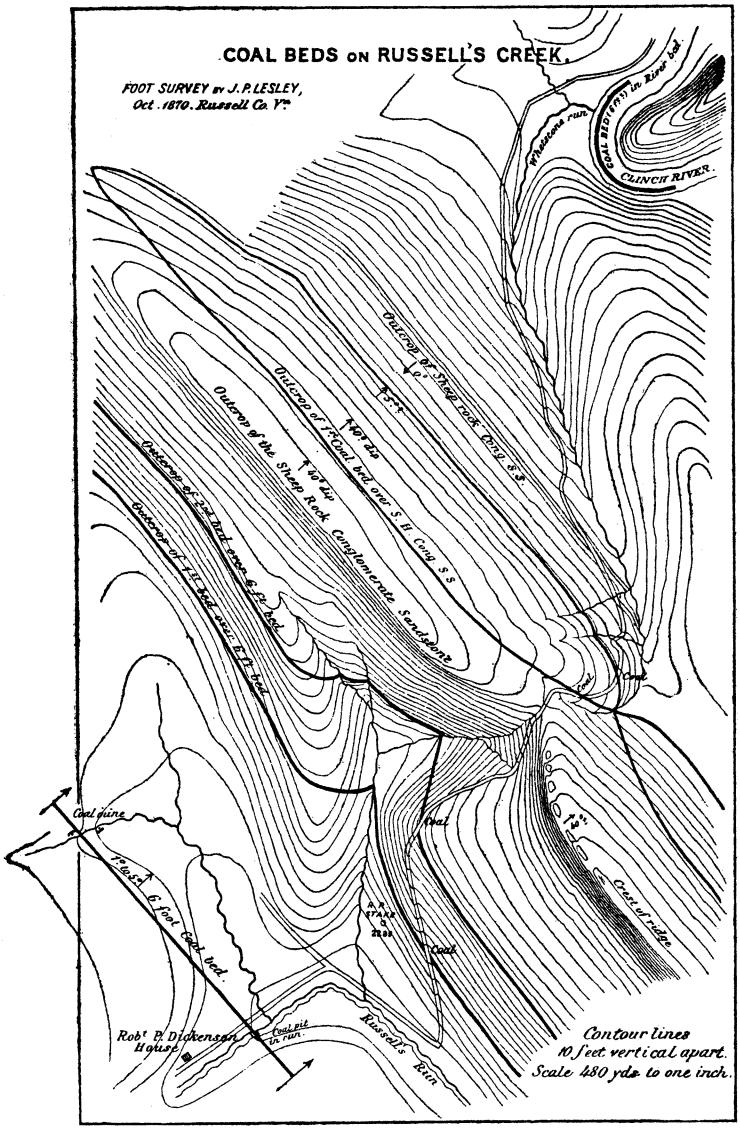
The following section up the side of Robert's Butt, half a mile north of Guest's Station, was made with an aneroid barometer. It shows the Sheep Rock Conglomerate Sandstone to be about 700 feet above the (Newberry, Robinet, Grier, Jessee, &c.) Six-Foot Coal Bed:



At one place where the bed has been dug a little into, it yields the best kind of bituminous coal, fat and caking, but friable, with no appearance of sulphur, and making no clinker. It is good blacksmith-coal, and no doubt will make good coke. A piece of ill-made coke from what is, perhaps, the same bed, near Gladesville, shows that the best coke can be got from it.

On *Russe's Creek* this coal bed is also at water level and has been mined by Robert P. Dickenson in the bed of the creek, near his house, and in a run a quarter of a mile further east, where a horizontal gangway has been commenced. About 5 feet of the coal is visible; the bottom is not reached, being in water. Roof: a shaley clay, without distinct plant impressions. Upper part of the bed bituminous, and somewhat bony. From the first 12 inches downwards, solid, and somewhat like cannel. Coal in some parts slightly granular, reminding one of the sand-coal of Montgomery County. Bottom coal very good for blacksmithing; makes a hollow fire; but cakes little and goes out before morning; not much ashes; ashes white; makes a yellow blaze; no sulphuret of iron visible; no fossil leaves. Streaks of coal through the bed showing

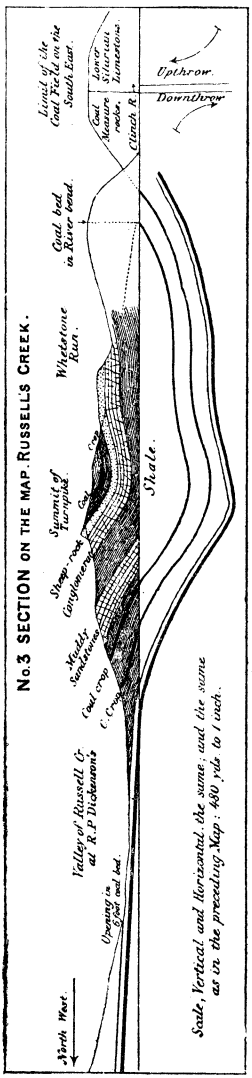
numerous minute discs of sulphuret of iron in the fissures; so that an analysis of the bed as a whole will give a notable percentage of sul-



phur; and it will be extremely difficult to pick the coal, if mined extensively, so as to furnish it free of sulphur. It is, however, on the whole, a satisfactory bed; and its harder benches will bear carriage well.

The bed dips at least 5° southward at this precise place; but not so much over a larger area. Over it are thin slabs of shaley sandstone, with large calamites and stigmaria stem impressions; and over these again a small coal bed; which cannot lie more than 20 feet, if that, above the other bed.

I made a careful survey of the hill to the south of this place, the summit of which is made by south-dipping conglomerate sandrocks (Sheep Rock of the last section); and found two coal beds outcropping on its north face, and two more on its south face, descending Whetstone Run to Clinch River. This run has a conglomerate terrace on its left bank, and is rendered very rocky by the descent of fragments of rock.



Section No. 3 on the map is the most instructive I could obtain in this district of the region, and requires no explanation. It shows that the distance from the Six-Foot Bed up to the Sheep Rock Conglomerate is everywhere about 700 feet, and contains at least two coal beds; and that there is one more coal bed above the conglomerate. I had no means of determining the size or quality of any one of these three beds; but they are all, probably, under 3 feet.

The above sketch-map and this accompanying cross-section (No. 3) were measured on the ground and drawn to scale. They enable me to speak of only *one* coal bed above the Sheep Rock Conglomerate, with two outcrops on this road, looking like two coal beds. Further east, as will be seen, this bed (?) has several others over it.

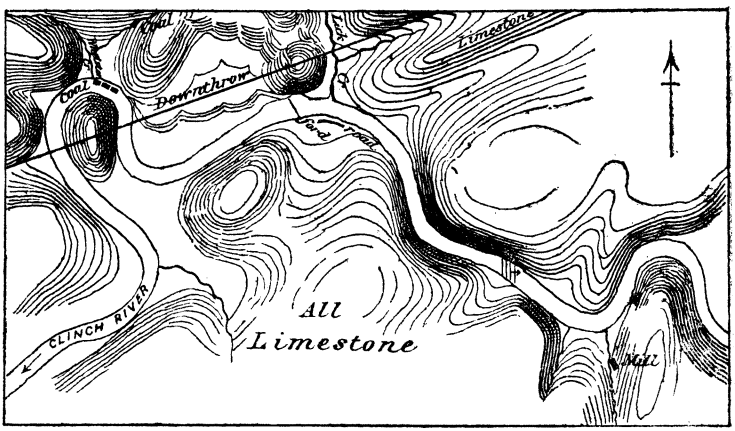
The section renders it doubtful whether the coal dug at lowest water in the bed of the Clinch at the mouth of the Whetstone be the six-foot bed. It looks more like the second bed above it. But the southeast end of the section is a little obscure, and I had no time to study the exact character of the Downthrow of the Coal Measures against the limestones* at this point. It runs through an isolated hill, quite surrounded by a bend of the river, as shown in the sketch-map on the next page.

* Query.—Do these belong to an outcrop of the subcarboniferous limestone issuing from the fault?

The map below will give a better idea than any verbal description of the difficult nature of the ground for railroading purposes down Clinch Valley. The hills are from 200 to 300 feet high and present bold and massive cliffs of Lower Silurian limestone to the river.

It will also illustrate the general law that the principal rivers and large streams of this region of Virginia run in the lower members of the Lower Silurian limestone system, as they habitually do elsewhere, near the edge of the Freestone Carboniferous land. The cause of this is evident. The surface of the country as it is at present has been produced by the removal of all the geological formations above that which now forms the surface. When the Downthrows were first formed the drainage of the

SKETCH MAP OF CLINCH RIVER,
where it strikes the Coal Measures and rebounds, at Lick Run.



country was down the face of the Coal Measures to the crack and then along the crack sideways. This produced a very slow erosion of the Coal Measures, because of their numerous massive bed of sandstone. But the drainage along the cracks produced great erosion into the face of the sandy and magnesian limestone exposed by it. The drainage from above also produced caverns in the limestone. Out of these caverns issued streams which swelled the rivers which ran along the cracks. The formations over the limestone were worn rapidly away. The face of the limestone wall of the crack was worn back. And so, by the time the present surface level was reached, the rivers, which originally flowed on the Coal Measure side of the cracks, had got their valley-beds fairly established on the limestone side of the cracks; and, sometimes, at a considerable distance on that side.

As the lower limestones are massive and very soluble all the streams of the region which flow through them have extremely rough and tortu-

ous valleys, walled in at intervals with cliffs. The smaller streams head up in smooth valleys (of the upper limestones and slates of the Lower Silurian system) admirably fitted for railroad locations. But near their mouths, where they cut rapidly down through the lower limestones to flow into the cross streams, their beds are full of jagged rocks and their valleys difficult for cheap railroading.

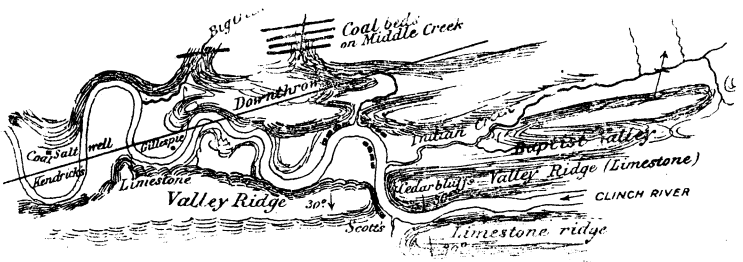
It is among these lower limestones that the beds of *brown hematic iron ore* lie. For instance, the cliff at the river bank, just where the road from the west along the north bank comes to the ford at the mouth of Lick Run, is a mass of sandy limestone, near the bottom of the Lower Silurian system. Further up the north bank of the river, east of Lick Run, is a long limestone hill on which many pieces of the ore are scattered, some of them very large. There is a good chance here for the existence of a valuable iron-ore deposit on a large scale. The ore is good.

THE COAL FURTHER EAST.

I made no detailed examination above Lick Run for a good many miles; and I have mentioned in a Summary Report the streams crossed by the coal beds in this interval. I will only add here, that some of these beds were *reported* to me as ten (10) feet thick. The six-foot bed may become thicker at points which I did not visit than it is where I saw it.

The "Mouth of Indian" is a thriving little village on the north bank of the Clinch where it enters Russell County. I surveyed this neighborhood carefully, because the coal beds here have been opened more extensively than elsewhere; because they stand at a higher angle and give a series; and because the downthrow is exhibited in a most curious and instructive manner. The river breaks through limestone just above Indian Creek mouth, forming bluffs called the Cedar Bluffs. A dam was built here forty years ago out of red cedar logs which has never needed repairs. It is fifteen feet high and backs the water two miles. Middle Creek descends from the north and enters just below Indian Creek.

Up Middle Creek are the coal mines. See the following map:



Two miles further down the river, Big Creek runs across the upper end of the wide and fertile bottom called the "Rich Lands," at the farm of Mr. Gillespie.

Two miles further west, a salt well, 354 feet deep, was sunk at the north edge of the river bottom, on Mr. Kendrick's land, twenty-two (22) years ago, and, at 337 feet, went through 6.7 (six feet seven inches) of

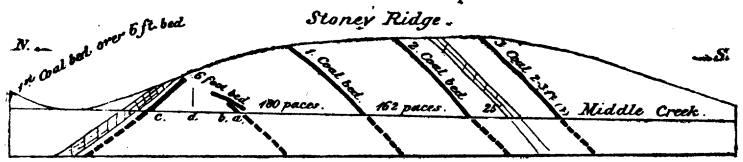
coal. Six feet at the top of the well was mud. All the rest was "sandrock," without coal.

Petroleum.—There was enough oil to grease the rods. The well was plugged up. Recently the plug was knocked out, when *fresh* water spouted from the 3½-inch hole to a height of three feet, but soon subsided. A film of oil stands on the water, which is very cold and too brackish to taste perfectly good, although cattle go to it in preference to drinking other water.

Salt.—The spot selected for the well had been a famous deer and buffalo lick. The ground had been eaten away by the animals. Thirty or forty deer used to be seen at one time at this lick; and spoonfuls of salt could be collected. It must be borne in mind that the salt wells of Eastern Kentucky get their water from the conglomerate at the base of the Coal Measures. There must, therefore, be a saltwater-bearing formation several hundred feet below the coal bed at the bottom of this well; supposing, 1, that it is the Six-foot Bed of Wise County; and supposing, 2, that the Sheep Rock Conglomerate Sandstone is *not* the true Conglomerate Base of the Coal Measures. But even if the latter supposition be wrong, and the Six-foot Bed be one of the Sub-Conglomerate Coal Beds of Eastern Kentucky, which is quite a possible thing, there remains a still lower "Knobstone," or Devonian Saltwater-bearing Formation, from which the salt water must find its way to the surface through the Great Downthrow and cross-fissures connected with it. This Devonian Saltwater-bearing Formation is that which supplies our deep salt wells in Western Pennsylvania, and is also the same as the Petroleum-bearing Formation of Venango County.

THE COALS AT MOUTH OF INDIAN.

(Section No. 6 of the Map.)

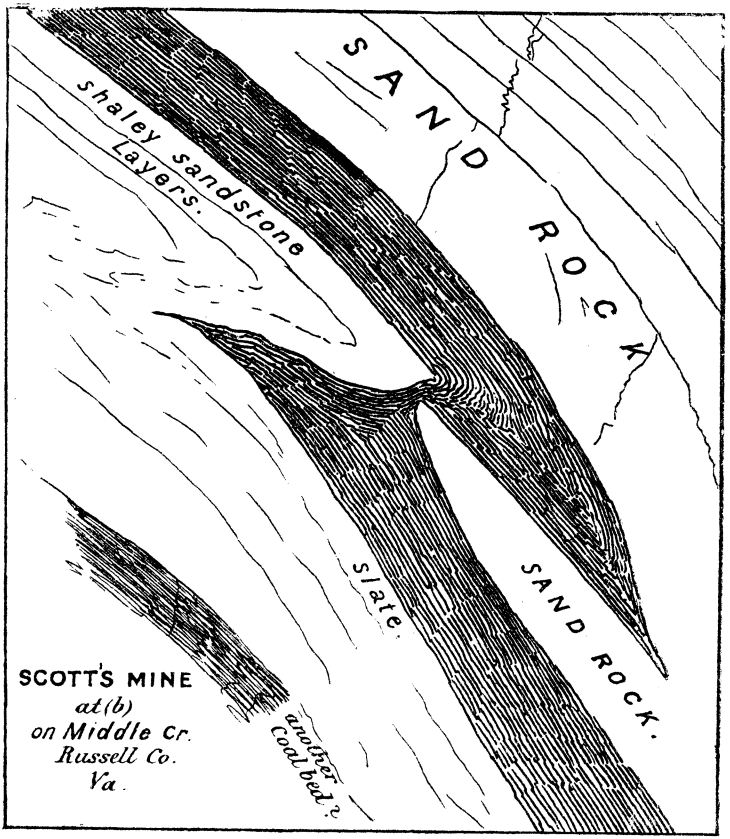


The Six-foot Coal Bed, here, has been opened and mined for the use of the neighborhood by Mr. Scott, at (*a*) about 1½ miles up the creek from its mouth; and again at (*b*) a quarter of a mile further up, on the same south dip. At both (*a* and *b*) it shows a disturbance represented in diagram on the next pages.

The bed is here, really, but 2½ to 3 feet thick. It is covered with a plate of sandstone which is several feet thick; and, although the pressure produced by the Great Downthrow, which runs along at a distance of about half a mile due south of the locality of the mine, has folded the coal bed *with* the sandrock back upon itself, yet the sandstone of the rock, thus caught in between the walls of the fold of the coal, is perfectly solid and does not show the slightest trace of disturbance. This is a striking, but well-known phenomenon. The coal itself is bent round, and shows sharp tongues, in the fold.

At (*b*) the same sandrock is equally folded and unbroken, as the following diagram (looking in the opposite direction, *i. e.* east) will explain.

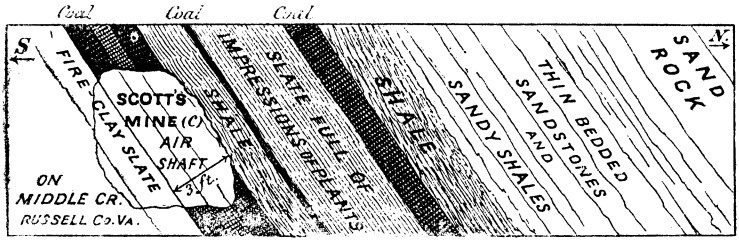
Here, also, the bed, which when doubled measures 5 or 6 feet thick, is really but a three-foot bed. There is nothing, in fact, to identify it with the "Six-foot" coal of Wise County. But it may very well be the 6.7 coal of the Salt Well, three miles distant.



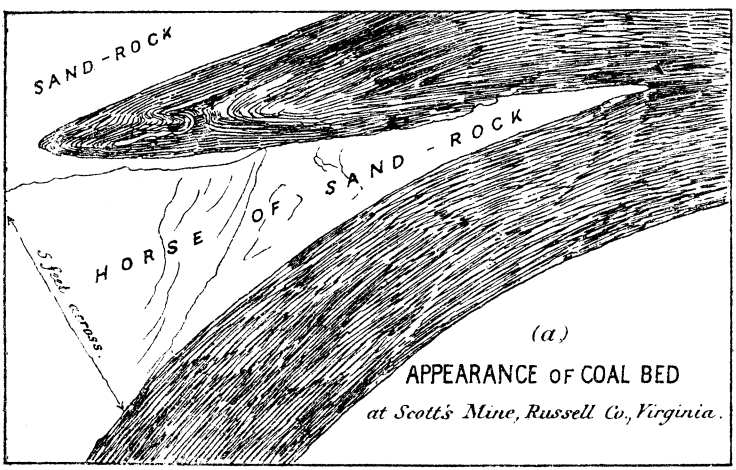
It is opened again at (*c*) some hundred yards higher up the creek, and on a *north* dip of 50°. The Confederate army mined it pretty extensively. It is here three feet thick, in three benches each a foot thick. The top and bottom benches good, the middle bench bony. Over it are three or four feet of slates, and then comes a one-foot bed of bony coal. The report goes that the miners found these two coal beds close together, down below; making thus one very fair *four-foot coal bed.* A diagram on the next page shows the whole exposure in position.

All this is not very encouraging for the coal trade. But the same bed has been opened at (*d*), directly on the crest of the anticlinal, which has here sunk (running in an easterly direction) to the level of the creek. Here

the coal lies flat in the water; and several pits, sunk through it, are deeper than the height of a man. The bed must be nearly, or quite, six feet, and yields good coal (as indeed it does at the other openings); but what its constitution may be I do not know. It is probably subdivided into benches of different qualities; and, no doubt, has some of the slate of the above last section running through it. Its position on the anticlinal will make mining difficult.



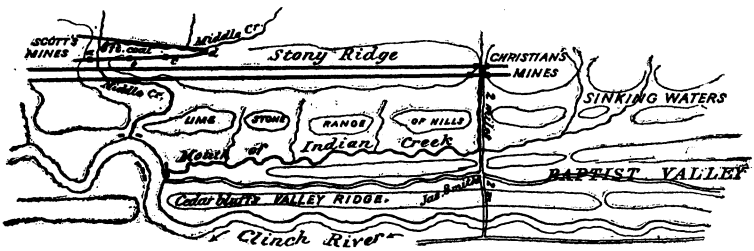
The anticlinal disturbance at Scott's Mines on Middle Creek must be local; because the topography around the Salt Well shows that the Coal Measures *there* come up to the Downthrow in a flat and undisturbed condition; and the dying down of the crown of the anticlinal in the Six-foot bed so rapidly that the bed lies flat in the creek only a few hundred yards above where it plunges at angles of 40°, 50° and 60° proves the same thing.



Nevertheless, the very steep dips of the overlying coal beds and rocks throughout the body of Stony Ridge makes the whole disturbance of considerable magnitude; and I have no doubt that when it is well examined to the eastward, it will be found to run in that direction some miles; not, perhaps, as an anticlinal but as a downthrow; and it may very well be the Abb's Valley Downthrow, of which more hereafter.

LAUREL RUN COALS.

Leaving the curious topography of the Big Creek, Middle Creek, and Mouth of Indian Downthrow to be described hereafter, in connection with Paint Lick Mountain and its Iron Ore, and going east up Indian Creek Valley, I can only report coal mines on Laurel Run, a side branch coming into Indian from the northwest. Mr. Christian has here opened several beds, one of which is reported to be *much over* six feet thick. The coal is wagoned to the county-town of Tazewell, Jeffersonville, fifteen or seventeen (15 or 17) miles distant. The following sketch will show how the coal comes out to market—two miles to James Smith's, on the Baptist Valley Road (beautifully engineered, at low grades), formerly a turnpike, and still the highway between East Kentucky and Middle Virginia; two miles to the Clinch Valley Road; thirteen miles by either of these two roads to Jeffersonville:



What the character of the Christian Coal is I do not know by personal inspection; but it must come from the same beds, and be essentially similar to the Scott Coals, and also to the Abb's Valley Coal next to be described.

Just east of the Christian Mines runs a limestone valley, along the south side of the Downthrow, in which the waters sink into caverns. It is called "Sinking Waters." Any one familiar with Abb's Valley (15 miles further east) will see at once, that the formation is the same; but I will show that Stony Ridge separates the two valleys and that the coal areas which I have been following all the way from Wise County are cut off, or whittled down to a fine point, opposite Jeffersonville. The next cross-section, No. 8, will show how this is done, and also how the Abb's Valley coal beds are brought down to the present surface by quite a different Downthrow from the one we have been tracing thus far, all the way from Guest's River in Wise County; a Downthrow *behind* and to the *north* of this one; as the map in colors will also help to show.

The Clinch Valley Downthrow, going east from Indian Creek, catches in its jaws a less and less number of beds and width of coal ground, until at last, on crossing the great road from Jeffersonville north to Tug Fork of Sandy, it holds but the lowest coal bed, standing at a high angle and very little of it left.

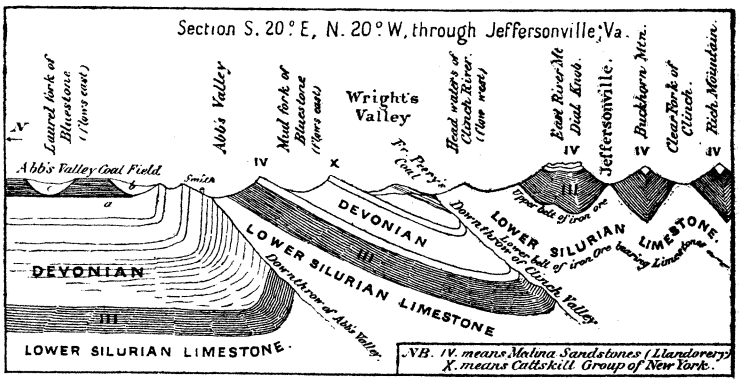
This is seen on the Section No. 8, marked Captain Frank Peery's Coal. How far east along this crack this coal can be traced: I do not know; but nothing of value can be expected from it; which is a great pity; for at this point *easy* access to the back country ends.

To get over into the Abb's Valley Coal Fields, two mountains must be crossed, or, rather steep stony hills, consisting of all the formations from the coal down to the limestone; especially Sandrocks X (Catskill) and IV (Shwangunk) here much diminished in thickness; which accounts for the comparative lowness of these mountains when compared with the high mountains formed by the increased outcrops of these formations in the Northern States.

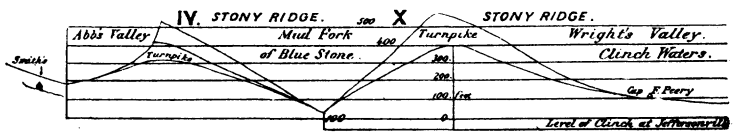
The deep rapid rocky bed of Mud Fork of Bluestone lies between the two mountains and descends eastward. Where the turnpike crosses it it is 400 feet below the notch in the crest of the first mountain, X (say 550 feet below the crest itself); and 250 feet below a slight notch in the crest of the second mountain, IV. This crossing of Mud Fork is, by barometer, on a level with the Jeffersonville Court House, and about 100 feet higher than the Clinch two miles east of Jeffersonville, at the west end of Wolf Creek Valley.

(Cross Section No 8, on the Map)

SHOWING THE ABB'S VALLEY DOWNTHROW.



The turnpike summit crossing the first mountain (X) is 300 feet above Captain Frank Peery's, on the head-waters of Clinch (6½ miles north of Jeffersonville). Clinch and Bluestone run in opposite directions along Wright's Valley; Clinch westward, Bluestone eastward. The divide between them is about 1¼ miles east of the turnpike, at Frank Peery's, and say 100 feet higher in level. This route from Greenbrier to Tazewell is feasible, but it is needless to try to get coal out that way.



Mud Fork of Bluestone heads up rapidly westward of the turnpike, and yet the valley between X and IV must continue on between the two Stony Ridges from the very necessities of the case.

Abb's Valley is produced by a great upthrow of the Lower Silurian limestone against the Coal Measures. The turnpike enters it almost at its head, or western end. From the notch in IV through which the road passes, to the Dry-water course in the centre of the valley is a descent (by barometer) of only 110 feet. Westward the valley rapidly fills up, and that is the course to take in locating a railroad from the mines out to Jeffersonville. A feasible route may be obtained, I think, by keeping up Abb's Valley to and over its divide, and down Cavitt's Run to the Clinch, two miles west of Jeffersonville.

The cause of the heading up of Abb's Valley and Mud Fork Valley so suddenly westward, and against what seems to be the main body of the Tug Fork of Sandy Coal Measures, is a most interesting and important affair, which should be investigated. I can only conjecture it. I take it to be likely that the Abb's Valley Upthrow of limestone starts across the Measures southwestwardly, becoming less and less of an upthrow, and thus swallowing down from the surface first, the Lower Silurian limestones of Abb's Valley, and then the shales and sandstones of the two stony ridges IV and X; and that it finally merges in the Clinch River Upthrow. At all events, such a geology would result in a topography of this sort: The limestone and shale valleys would head up suddenly against a ridge composed of Coal Measures Conglomerate or Sandrocks.

My advice is, that no coal-freight railroad line be sought for in the direction taken by the Jefferson and Tug Sandy Turnpike. But, on the contrary, that a line be sought further west, more down the Clinch, viz.: up Cavitt's Creek. Let the coal beds there be carefully explored, and a line be found across the divides beyond the west line of Abb's Valley.

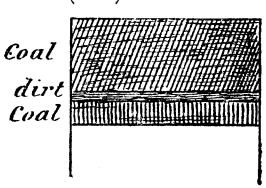
ABB'S VALLEY COAL.

Fifty feet below the summit of the hill, shown in the "Local Map" on the next page, and nearly 150 feet above the coal bed at its base, is a layer of very coarse, gray, friable sandstone, weathering yellow, without pebbles. Over it a tree has turned up a coal crop.

The coal bed below is, perhaps, the only workable bed of this district. For, after descending, at a slope of one or two (2°) degrees, south 20° east, through the base of the hill, and getting under water level, it seems to turn up suddenly and quite vertically, and to outcrop along the bottom of a little valley. It has been mined a little close to the turnpike (*b*) and Mr. Smith reports it to be "as wide as a room."

Ten miles east of this, and in a similar position, a coal bed is mined, which I judge to be the same one, and it is called ten (10) feet thick.

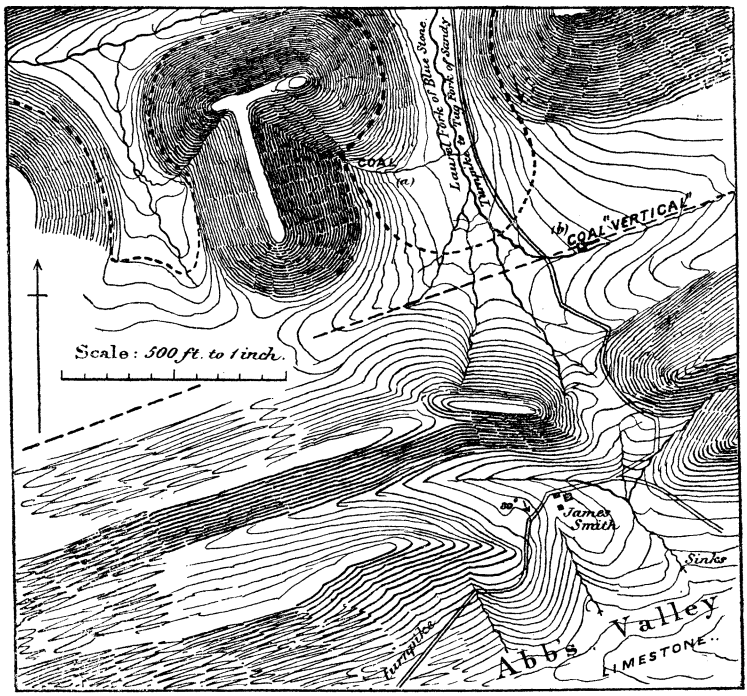
In the openings at the foot of the hill (at *a*) it has been merely thrown out from the water of the little brook. Mr. Cochrane, who has dug coal all through this region, gives its thickness as (5) five feet of coal in $5\frac{3}{4}$ of space. A dirt bed, four inches thick, separates the lower bench of very fine coal from the upper and main body of the bed.



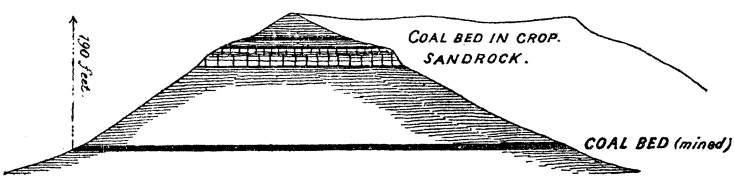
This coal bed is dug into by the farmers, at several places on the hill-sides of Laurel Fork, from half a mile to several miles north of Smith's coal. It is called six feet thick. Cochrane says he has dug it on Laurel where it was good seven feet.

LOCAL MAP OF ABB'S VALLEY COAL.

(Properly Blue Stone Coal.)



CROSS SECTION OF COAL IN HILL.



The level of the coal opening is (by barometer) 115 (one hundred and fifteen) feet above Smith's house; which house is 125 feet below the summit of turnpike crossing, Stony Ridge (No. IV). [See p. 504.] The coal and the turnpike summit are, therefore, nearly on a level.

From these coal outcroppings just back of Abb's Valley the coal field

of West Virginia and Eastern Kentucky extends, without a break, to the Ohio River. And the south edge of this coal field is the north ridge of Abb's Valley. The coal beds can be opened anywhere in the hills, just north of Abb's Valley; and several low windgaps, similar to that at Mr. Smith's, give the people of the valley access to the coal field. But, as I have said before, the railway line which passes through Tazewell must approach the coal field from the west—not from the south; around the head of Abb's Valley, from Cavitt's Creek. This will also subserve the interests of any railway projected from the Ohio River up Tug Fork of Sandy to Jeffersonville.

(N. B.—I do not feel entire confidence in my geology of the sandstone ridges at Smith's,—the ridges which form the north boundary of Abb's Valley. They need much more careful study than I could give them.)

THE IRON ORES OF II AND V.

The valleys of Tazewell and Russell, in Virginia, being geological, as well as geographical, prolongations of the interior limestone valleys of Pennsylvania, such as the Nittany, Morrison's Cove, and Kishicoquilis, contain necessarily the same kinds of ore, in the same formations, and in the same conditions. I mean that the unbroken ground is at present covered with patches of brown hematite "blossom," just as the ground used to be where our charcoal furnaces stand; and that the color of the road and field soil is the same as that of our best iron ore banks; the limestone rocks project in the same style, have the same internal composition, and exhibit the same corroded and dissolved surfaces; and potholes, caverns, and sinks abound along certain lines of outcrop. All these things are now known to bear an intimate relationship with both the original setting free of the mineral iron from the limerocks, and its subsequent deposit and consolidation. And it seems to be becoming clear to our geologists, that while there are regularly stratified beds and belts of the ore at two or three distinct horizons in the Lower Silurian Limestone Formation, which may be traced for many miles along the strike of the rocks, there are also vast accumulations of this brown hematite ore along anticlinal axes, especially wherever these are fractured; or degenerate into pure upthrow faults. It stands to reason that such a line of fracture, with a high wall on one side of it, should, in the course of thousands of ages, have collected vast quantities of the peroxidized iron which was being, through all these ages, set free in the slow dissolution of the limestones and the reduction of the whole mass of upheaved country to its present level. To say nothing of the facility afforded by such fissures to the decomposing and recomposing agency of drainage waters.

It is along the great upthrow fissures, then, that we are first to seek the iron ore deposits of this section of Virginia. And such a spot was pointed out to me near the mouth of Lick Run, on the hills bordering the north bank of the Clinch River, in Russell County, at section line No. 4 upon the map. Large masses of "blossom" lie scattered about the fields.

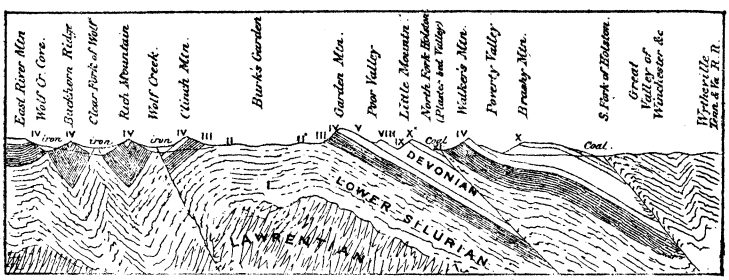
Similar shows of ore occur in other places. The hills southeast of Jef-

fersonville, just outside the town, show the existence of ore beneath the surface. Great quantities are reported two miles east of the town; and still more abundant exhibitions in the cove of Wolf Creek, behind Buckhorn Ridge, north of the forks of Wolf Creek, and opposite Rocky Gap. Immense shows are reported in Wolf Creek Valley, inside of (or south of) Rocky Gap.

I have myself no doubt of the correctness of these reports, so far as surface exhibitions are concerned. And it is an old and good iron master's maxim, that where there is plenty of blossom there will be plenty of good ore. The fact is geologically exact. For the blocks of ore on the surface of limestone land (like the masses of white quartz on the surface of a mica slate country) are the undissoluble parts of the original country left behind by the slow and imperceptible mouldering away and removal of the softer material.

A downthrow fissure, also, traverses Wolf Creek, at the foot of Clinch Mountain, as shown in the following continuation of section 8, and this fissure brings the No. IV sandrock of the mountain (which surrounds Burke's Garden) at a dip of 30°, down against the limestone of the valley. How far this fissure extends eastward I do not know; but certainly beyond Rocky Gap.

CONTINUATION OF SECTION No. 8 (OF THE MAP) SOUTHWARD.



There is also a sharp, broken anticlinal axis running through the valley of the Clear Fork of Wolf Creek, and this would favor the accumulation of iron ore. Another traverses the cove behind Buckhorn Ridge, cutting it off from East River Mountain. It is on this anticlinal that the Wolf Creek Cove ores exhibited.

But there is another important fact not to be lost out of view. Through out Southern Pennsylvania, and as far eastward (along the belt of which we are treating) as the Lehigh and the Delaware, and so on through New Jersey in the one direction, and through Maryland and Virginia in the other direction, the horizon (or formation level) of the bottom of the Lower Silurian (formerly called "Hudson River") Slates, No. III, and the top of the Lower Silurian Limestones, No. II, is a plate of brown hematite iron ore-bearing rocks. Many of our best and oldest mines, like the Balliott and the Moselem, between the Schuylkill and the Lehigh, are on the outcrop of this horizon, at the top of the limestone formation. Where

the dip is low and the slates of No. III are thick, this line runs through the middle of our limestone valleys. Where the dips are steep and the Slate Formation No. III is not so thick, the latter forms the flank of the mountain, and the iron ore line runs at the base of the mountain. Where a closely folded anticlinal makes the valley so narrow that the two bases of the opposing No. III Mountains touch each other, and the ridge of the limestone formation No. II, juts up along the water course, or does not quite come to the surface (as in the three valleys at the left hand side of the above Section No. 8), the iron ore deposits must be abundant.

Holding these simple principles of structure in mind, it is evident that the great iron bearing formation, at the base of the No. III Slate Formation, keeps its character all through Middle and Southern Virginia, and will be as rich and certain a basis for large iron mining and iron smelting operations as any other and better known section of the Appalachian Mountain Belt between New York and Alabama.

An old forge at the west end of Paint Lick Mountain (between Lebanon and Jeffersonville) used this top-limestone-horizon ore; and I have no doubt of its abundance in many other places. It is more constant and regular than the ores further down and near the bottom of the Limestone Formation No. II. And these, moreover, are often swallowed up to such a depth by the downthrows as not to be attainable for many years.

It remains to notice a quite different variety of iron ore, which, I hope, will prove sufficiently abundant at a few points along your line of road. It is the Fossil Ore of V; the Paint or Dye-stone Ore of Tennessee.

To describe the situation of this ore, I must refer to the map accompanying this paper. I have colored Formation No. V, the red shales of the Clinton Group, with the color which I gave it on the State Geological Map of Pennsylvania. This color, however, is not appropriate to the formation in Southern Virginia; for the *red soil* and *reddish* (Upper Silurian) *sandstones* which mark the slope sides of our Pennsylvania Mountains (of No. IV), gradually disappear as one goes south from the Potomac, giving place to a gray soil and very slightly, often not at all, reddened sandstones and slates. On the other hand, the opposite side of the mountain, where the basset edges of the (Lower Silurian) slates of No. III crop out, is very red. A Pennsylvanian geologist floating over the country in a balloon would naturally make the mistake of just reversing the geology of the mountain, and would descend upon the wrong side of it to seek for the well-known and highly prized fossil ore bed of Danville and Frankstown.

In spite of this change of color in the formation soils of the region, I have thought it best to retain the red color for No. V upon the map, seeing that it represents the blood-red color of the fossil ore itself. One may see, then, by tracing the lines of color on the map, where the fossil ore bed *ought* to be; whether it be there or not. Very extensive and costly explorations have been necessary in Pennsylvania and Maryland. No doubt much research of the same sort will be called for in Virginia. But the ore is there; and, as in Pennsylvania and Tennessee, it will run for

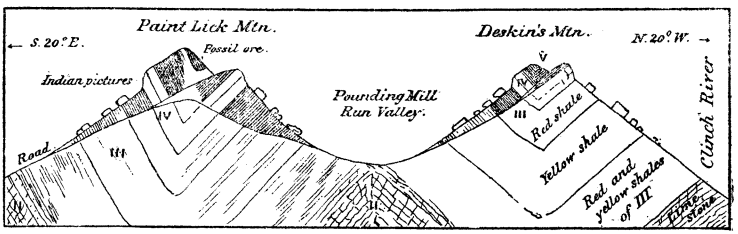
miles together in a workable condition as to size and posture, and prove a source of wealth.

The principal use of this ore is to mix with other varieties,—with the blue carbonate lean ores of the Coal Measures, especially; but also with the inferior grades of brown hematite. The time will come when it will be smelted in connection with the primary ores of the Blue Ridge Range and Smoky Mountains.

The forge which stood many years ago at the west end of Paint Lick Mountain, in Russell County, used this ore, and obtained it from the summit of Short Mountain to the south.

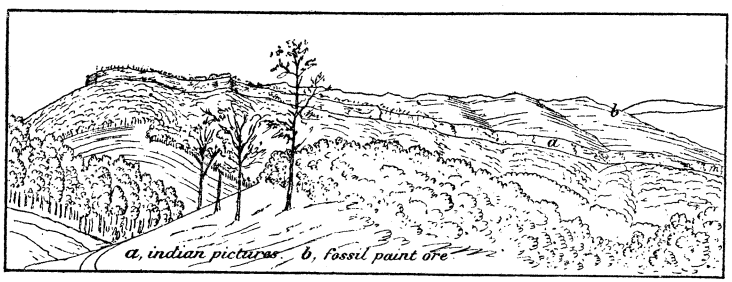
Paint Lick Mountain is named from an exposure of this ore on its summit. The situation is one of peculiar interest to the geologist and to the antiquarian.

CROSS SECTION AT THE ROAD FROM THE CHURCH TO CLINCH RIVER ABOVE CEDAR BLUFFS; AT LYLE'S GAP.



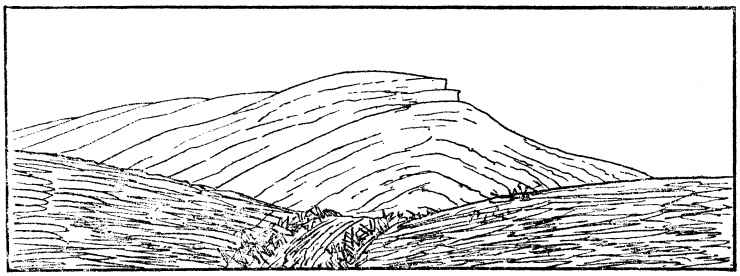
A cross-section, at the road over the mountain, through a notch called Lyle's Gap, will show the cause of the appearance of this ore in so singular a position. It is confined to the very summit of the mountain for some distance midway between the two ends, and to the west of the place where the road crosses. Its thickness and extent is unknown, nor do I think that more than a few thousand tons of it are to be expected. The ore stratum has been swept away from all other parts of the ridge of the mountain, and no trace of it has been left upon Deskin's Mountain; from

PAINT LICK MTN, FROM THE SOUTH; CLIFFS AND ORE.



which, indeed, the great sandrock No. IV has almost disappeared; a few house and barn-like masses being left standing at its western end in most picturesque style. House and Barn Mountain is a prolongation of Paint

Lick synclinal westward and is named from two masses of No. IV, left upon its summit, visible from all the surrounding country. Dial Knob (East River Mountain) and Buckhorn Mountain are prolongations of Paint Lick and Deskin's synclinals, eastward beyond Jeffersonville, and Dial Knob may have a good deal of fossil ore left upon it in the cove, behind the Dial Cliffs; but Buckhorn has lost the ore. So has the whole range of Rich Mountain, from Rocky Gap west, to Morris's Knob, which is terminated by one of the most remarkable cliffs of No. IV I ever saw (see its profile below). Short Mountain is a prolongation of Rich Mountain westward, broadened by a shallow synclinal which must hold large quantities of the fossil ore. The synclinal of House and Barn Mountain is prolonged westward (past Lebanon, far down Clinch River) as a downthrow of the No. V Formation against the limestone of No. II; and all along the south side of Copper Ridge there runs a south dipping plate of



DOUBLE ESCARPEMENT OF No. IV. 200 Ft. WALLS,
at the Westend of Rich Mountain. Morris Knob, Russell Co, Va.

the fossil ore, which has been opened, in old times, at one point, and used in a now abandoned forge. There must be immense quantities of the ore in this ridge. It is known to the inhabitants, however, only as a paint. But this will be a sufficient guide to the iron master.

The Indians used the outcrop of the fossil ore bed to paint their faces and lodges. The deposit on Paint Lick Mountains was a famous locality among the Aborigines. On a smooth perpendicular wall of sandstone, facing southward, and visible from General Bowen's house and the Maiden Spring, there remain numerous pictures and symbols of men and animals in red paint, fresh as when first made, and older than the settlement of the country by the whites. I give above a view of this long wall of sandstone cliffs as I saw it from the Lebanon–Jefferson turnpike; and, when taken with the cross-section, it will explain without further words both the structure of this (and other similar mountains) and the cause of the small amount of fossil ore left upon its summit, and the total disappearance of the last remains of the ore deposit from the summits of House and Barn, Desmit, Buckhorn, and Rich Mountains.

But there are extensive outcrops of the fossil ore of No. V along Poor Valley; in fact the deposit (whether rich or not remains to be discovered) runs uninterruptedly more than a hundred miles in an almost mathematically straight line along the south flank of the Clinch Mountain from

Tennessee, past Moccasin Gap, back of Saltville, past Sharon Alum Springs, to Hunting Camp and Kimberling Creeks, and so on, eastward, across New River towards the James River country. No doubt some sections of this line hold the ore bed in a lean and, perhaps, unworkable condition; but it is quite incredible that other sections will not have it both thick and rich.

Now it is along this Poor Valley and its outcrop of iron ore that Gen. Haupt locates the line of railway.

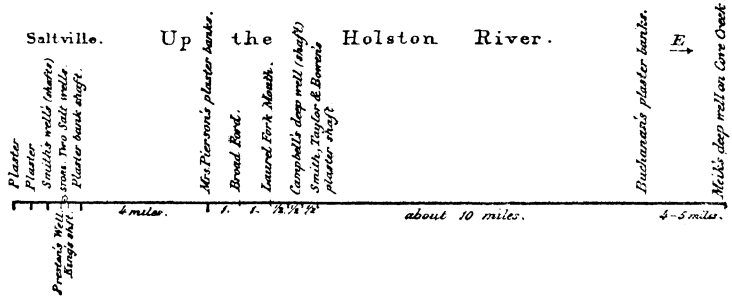
Even if the Clinch River line be adopted, for the sake of the coal and for other reasons, a branch road must certainly be made up Hunting Camp Creek to the Plaster Banks, at Saltville; and this branch will have the ore crop of Poor Valley, and the ore deposits of Tumbling Run, on top of Short Mountain, at its command. It can bring the fossil ore forward to the Forks of Wolf Creek, where are the before mentioned large deposits of brown hematite ore; and where it will meet the coal coming across from the Clinch River. Here, or somewhere lower down Wolf Creek, perhaps at its mouth, will probably be located one of the principal future iron-works of Southwestern Virginia.

THE PLASTER (GYPSUM) BANKS, AT SALTVILLE.

A sound theory of the origin of the gypsum can be, for the present, our only guide to a correct estimate of its quantity, where it is known to exist, and to its discovery elsewhere.

Gypsum may be produced by the action of free sulphuric acid on limestone; or by the action of sulphuretted hydrogen gas on limestone. One or the other, or both of these agents combined, have acted on the limestone rocks along the banks of the N. Fork Holston River, from Saltville, eastward for a number of miles, converting them into gypsum. The acid, whether in a fluid or in a gaseous form, has undoubtedly passed along between the walls of the great fissure which has thrown the Lower Coal Measures of the Poor Valley (Little) Mountain 15,000 or 20,000 feet down against the limestones; has soaked into the walls of the fissure; and has changed the limestone to gypsum for many yards on each side of the crack. Shafts have been sunk through solid masses of gypsum rocks thus formed to a reported depth of 500 and 600 feet, finding no bottom to the gypsum.

The story of this shafting as given to me by General Bowen is as follows:



Captain Smith and his son-in-law Mr. Robinson many years ago sank a line of shafts across the (tertiary or postertiary) plain on which Saltville stands, and *all of them* through gypsum *all the way down*. Others were sunk by Smith & Robinson, Campbell, Taylor & Bowen, Meik and others at other places in the Holston Valley for a length of twenty (20) miles, more or less, and up Cove Creek four or five miles still further east. No attempts were made to get the plaster further on towards Sharon Alum Springs; but there is nothing to intimate its non-existence except the absence of outcrops through the soil. These outcrops naturally existing, or accidentally exposed in farming, or by the railroad cuttings south and west of the village, have alone (as it seems) determined the search after gypsum in the valley. And as the Saltville people alone have any proper machinery for sending it to market, a stop has been put to all exploration elsewhere.

Moreovor, seeing that Capt. Smith struck a copious brine in two of his wells, the opinion early prevailed that the salt and the gypsum were geologically connected. This opinion induced a number of persons to sink *in the gypsum outcrops* not for gypsum but *for salt water*. As salt water was obtained in no single instance other than Capt. Smith's two wells, all hope of obtaining brine and making salt elsewhere than at Saltville has been long since abandoned; and consequently all exploration of the gypsum rocks, which had no commercial value to the salt-well borers.

It is therefore probable that the limestone wall (the south wall) of the Holston River Downthrow (Upthrow of limestone) will in course of time be discovered to be converted into gypsum at other points besides those specified above; and that the gross quantity of gypsum existing beneath the surface along this part of the Holston River far exceeds any estimate which I can make from the gypsum banks already opened. And for the same reason it is probable that the limestone walls of the other Upthrows of the region will be found turned into gypsum, at least in certain places, and in very considerable abundance.

The appearance of brine in such quantity and of such strength must be considered as a local phenomenon explainable without reference to the gypsum. Such an explanation may be found in the very curious lake-deposit of the little triangular plain of Saltville; a deposit evidently made in a deep little lake or pond basin filled with red mud saturated with salt-water, gypsum drainings, &c., &c. In this mud the salt-water has deposited rocksalt, and from this rocksalt deposit now rises the copious discharge of brine which furnishes all the supply needful for the extensive salt works. The salt lies in solid form, mixed and inter-stratified with compact red marl or clay, 200 feet below the water-level of the Holston; and the borings have gone down (at the Salt Works) 176 feet further without reaching the bottom! On the top of the deposits of salt and mud is a stratum of blue slate more than 100 feet thick. Over the blue slate lie 60 or 80 feet of gypseous clays. The limestone country being cavernous to great depths, and especially along the face of the Downthrow, it is not surprising to notice that the level of water stands the same for all the wells and shafts sunk at Saltville and rises and falls in sym-

pathy with the Holston River. This accounts for the inexhaustible supply of liquid. The heaviest pumping has no perceptible effect in lowering the level.

In 1853 the salt yield was 300,000 bushels; 50 lbs. to the bushel, and 6 bushels to the barrel; at 50 cents a bushel. Five furnaces were then running 24,000 gallons of brine pumped daily; 10,000 cords of wood burned yearly.

During the Civil War, four wells were pumped night and day for six months, and yielded 1,000,000 bushels of salt during that half year. There were then sixty-nine different "blocks of kettles" going. These kettles, broken and rusty, lie scattered about the valley for six miles, half buried in piles of burnt and broken down walls which represent the various works then in full operation. Some of the salt water was carried in railway tanks nine miles to Glade Spring Station on the Virginia and Tennessee Railroad, and boiled there.

At present there are three "blocks," of 80 kettles each, (5 bushel to a kettle) per 24 hours, making 360,000 bushels per year, of 300 days.

Preston's gypsum banks yielded 2000 tons in 1854; the cost at the mines, in lump, being $3, and in flour $5; eighty miles distant $20.

What the yield has been since and what it is now, I do not know. Operations are vigorously carried on at four or five shafts. Plaster is now sold at the mines for $2.50 the ton; at Sharon Alum Springs, 35 miles to the eastward, at $10, in wagons; and is carried forty miles further east for use upon the soil. Its virtues are well known and highly prized. It *doubles* the grass crop and grain, and greatly improves corn. One bushel of 100 pounds is sown to the acre.

A railway from Saltville east would find a market for all the plaster it carried. Plaster would go east to the Wolf Creek Fork Junction, and return by the other line to be used on the pasture lands of Tazewell and Russell and Wise Counties. But its greatest commercial outlet would be towards Staunton and Winchester.

Although the gypsum rocks have not the regularity of a coal bed, and some difficulties, of a kind peculiar to this district will be encountered when mining operations are extended to cope with the demands of commerce along a great trunk railroad, yet I see no practical limit to the capacity of the gypsum belt for exploration. Shafts five and six hundred feet deep have permitted the miners to feel the gypsum masses for fifty yards in width. Such a mass, limited by such a shaft, weighs six or seven hundred thousand tons, provided the gypsum be solid the entire depth of the shaft, &c., &c. This is not the case; neither, on the other hand, is the *width* of the column of gypsum limited to fifty yards, or to any other figure. Nothing can be more irregular than the masses of gypsum underground—unless it be the course to be taken to get it out to the surface. In spite of all mining difficulties the value and scarcity of the mineral in all other parts of the country must make its mining in this district always extremely profitable, and its railway carriage over long distances inevitable. It must always be in demand; can always pay a high freight charge, and cannot meet with competition from the Nova Scotia plaster until it arrives within a hundred miles or so of tidewater. Westward and southward it may go five hundred miles without meeting competition.